The Abyss of Time

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DOI:10.7312/columbia/9780231164481.003.0001

Abstract and Keywords

This chapter traces the roots of the idea of deep time, one of the most fundamental and surprising discoveries about the Earth during the twentieth century. In September 1846, William Thomson, then age twenty-two, applied for the chair in natural philosophy at the University of Glasgow. Before an appointment could become official, the applicant had to write and deliver, in Latin, an essay assigned by the faculty. Thomson’s topic was *De caloris distributione per terrae corpus*: “The distribution of heat within the Earth.” The title echoed that of Joseph Fourier’s book on heat flow, *The Analytical Theory of Heat*. The implications of Fourier’s mathematics, first encountered by Thomson at age sixteen, would occupy him for sixty-eight years, until his death in 1907. By then he was known as Lord Kelvin. This chapter also looks at the emergence of geology as a true science and the rise of uniformitarianism by focusing on the works of James Hutton and Charles Lyell.

Keywords: deep time, Earth, William Thomson, Joseph Fourier, heat flow, mathematics, geology, uniformitarianism, James Hutton, Charles Lyell

Gone Right Through It

In September 1846, the faculty of the University of Glasgow convened to examine an applicant for its chair in natural philosophy, the previous holder, appointed in 1803, having passed on after a lengthy illness. At age twenty-two, the candidate, William Thomson (1824–1907), was easily mistaken for a student himself. In spite of his youth, the Cambridge graduate had already accomplished more than enough to justify his candidacy, but there was one additional hurdle. Before an appointment could become official, the applicant had to write and deliver, in Latin, an essay assigned by the faculty. Thomson’s topic was to be *De caloris distributione per terrae corpus*: “The distribution of heat within the Earth.” The title echoed that of Joseph Fourier’s famous book on heat flow. Either Thomson himself or his father, James, a long-time member of the Glasgow faculty and his son’s strongest booster, had proposed the topic.¹ Both knew that no one was better qualified to address the question of the Earth’s heat than William, who at age sixteen had already mastered Fourier’s difficult mathematics.
William Thomson had learned of Fourier’s *The Analytical Theory of Heat* in 1839 from the lectures of Professor John Nichol, who told the teenager that “perhaps” he could understand this work of “transcendent merit.” According to William’s later recollection, “I took Fourier out of the University Library; and in a fortnight I had mastered it—gone right through it.” The following summer James Thomson took his children on a trip to Germany. Before leaving, William had picked up a book by Phillip Kelland, professor of mathematics at Edinburgh, titled *Theory of Heat*. Fourier, Kelland alleged, had made an error. Indignant at this slander of his hero and already a budding academic, William penned an article titled “On Fourier’s Expansions of Functions in (p.4) Trigonometrical Series” and submitted it to the *Cambridge Mathematical Journal*, which published it. The author was listed not as William Thomson but, at the suggestion of his father, as the pseudonymous P. Q. R. James Thomson evidently thought it inappropriate for his sixteen-year-old son to rebuke in print a distinguished colleague.

As further evidence that young Thomson’s essay topic had not been chosen at random, in 1842, at age eighteen, the precocious youngster had published a memoir titled “On the Linear Motion of Heat.” Using Fourier’s approach, he solved the differential equation that describes how to determine the temperature in a solid body at any time in the future. For the rest of his long life, William Thomson would return to this early paper and its implications, which “contain[ed] the germs of many of his subsequent ideas.” At the end of the paper Thomson speculated on the effect were he to assign negative values to time. The equations then gave impossible results, convincing him “that there must have been an origin to the natural order of the cosmos. There must have been a beginning.”

In looking back at his body of work from the vantage point of 1882, Thomson wrote that this youthful essay “gave a very decisive limitation to the possible age of the earth as a habitation for living creatures, and proved the untenability of the enormous claims for TIME which, uncurbed by physical science, geologists and biologists had begun to make and to regard as unchallengeable” (186).

The implications of Fourier’s mathematics, first encountered by young William Thomson at age sixteen, would occupy him intermittently but without surcease for sixty-eight years, until his death in 1907. By then he was known as Lord Kelvin, the world’s most acclaimed and accomplished scientist.

**High Priest of Uniformitarianism**

Just before Fourier began his mathematical advances, geology began to emerge as a true science. The pivotal insight came from the Scotsman James Hutton (1726–1797). Trained as a physician and chemical manufacturer, Hutton inherited several farms from his father, allowing him the opportunity to roam the land and pursue his interest in geology. Not content merely to observe, Hutton set out to explain.

Hutton believed that God had created the Earth for man. Since sections of the Earth are visibly eroding, some process must restore it; else our planet would eventually become uninhabitable, surely not God’s intent. Hutton came to believe that eroded sediments are deposited in the sea and subsequently hardened, heated, uplifted, and returned to the continents, where they erode to start the process again. He viewed earth history as a series of endless cycles of decay and rejuvenation, with, in his most famous phrase, “no vestige of a beginning,—no prospect of an end.”
This view contrasted mightily with the rival theory of geology, which saw earth history as ruled by catastrophe: earthquakes, volcanic eruptions, and the like. Catastrophism fit well with the short chronology of Archbishop James Ussher and his followers, which allowed only a few thousand years for all of geologic time. Hutton’s cycles required vastly longer periods. As his devoted biographer and interpreter, John Playfair, wrote, they required an “abyss of time.”

Hutton earned his position as the “Father of Geology” for a statement that would become the guiding principle of geologic thought and practice:

> Not only are no powers to be employed that are not natural to the globe, no action to be admitted of except those of which we know the principle, and no extraordinary events to be alleged in order to explain a common appearance ... we are not to make nature act in violation to that order which we actually observe ... chaos and confusion are not to be introduced into the order of nature, because certain things appear to our partial views as being in some disorder. Nor are we to proceed in feigning causes, when those seem insufficient which occur in our experience.

Charles Lyell (1797–1875) extended Hutton’s theory in a book titled *Principles of Geology*. The first edition appeared in 1830 and the last, published posthumously, in 1875. The book made Lyell the most influential geological writer in history. Trained first as a lawyer, Lyell’s *Principles* was a “passionate brief for a single, well-formed argument, hammered home relentlessly.”

Like Hutton, Lyell believed that God created the Earth for humans. But once he set the Earth going, never again did he intervene in its workings. Natural laws are invariant. Moreover, not only are the processes that we observe today the only ones that have ever operated, but they also have always operated at the same rate. According to Lyell, “If in any part of the globe the energy of a cause appears to have decreased, it is always probable that the diminution of intensity in its action is merely local, and that its force is unimpaired, when the whole globe is considered.”

Lyell disdained catastrophism, writing in 1881 that he needed no “help from a comet.”

According to Lyell, while change is constant on Earth, it does not lead anywhere. Our planet has always looked about as it does now, its history revealing no evidence of progress. Even extinction does not represent permanent change: “The huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyl might flit again through umbrageous groves of tree-ferns.”

Had the Earth been on trial with Lyell as prosecuting attorney, the defense might have pointed out that his thesis divides into two parts. First, natural law and earthly processes do not vary. This we may call the constancy of law and process. Second, neither the rate at which those processes operate nor the overall condition of the Earth vary. This we may call the constancy of rate and state. One could accept the first constancy without having to accept the second. In what Stephen Jay Gould has called “the greatest trick of rhetoric ... in the entire history of science,” Lyell gave both arguments the same name: “uniformity.” William Whewell, who reviewed the second edition of Lyell’s book, lumped the two meanings together under the unwieldy name “uniformitarianism.” which stuck. Whewell posed the essential question of geology: “Have the changes which lead us from one geological state to another been, on a long average, uniform in their intensity, or have they consisted of epochs of paroxysmal and catastrophic action, interposed between periods of comparative tranquillity?” He sagely...
predicted that the question “will probably for some time divide the geological world into two 
sects, which may perhaps be designated as the Uniformitarians and the Catastrophists.”

(p.7) The defense would go on to point out that the constancy of law and process, which Gould 
has called methodological uniformitarianism, describes not how the Earth works but how 
geologists ought to work. They reject supernatural explanations and employ commonplace, 
simple processes before appealing to rare, complicated ones. Of course, this is not the only way 
that science works; it is nothing more than common sense. William of Ockham expressed it well 
in the fourteenth century: “One should not assume the existence of more things than are 
logically necessary.” All scientists reason from effects back to causes. Nothing is special about 
methodological uniformity; it says merely that geology is a science.

Lyell believed so strongly in the uniformity of rate and state, which Gould called substantive 
uniformitarianism, that he wrote,

But should we ever establish by unequivocal proofs, that certain agents have, at particular 
periods of past time, been more potent instruments of change over the entire surface of 
the Earth than they now are, it will be more consistent with philosophical caution to 
presume, that after an interval of quiescence they will recover their pristine vigor, than to 
regard them as worn out.  

But by the late nineteenth century, geologists had already found unequivocal evidence that 
substantive uniformity is false: earth history is marked by change. Glaciers have advanced over 
the continents and retreated; seas have drowned the continents and withdrawn; mountain 
ranges have risen and worn away; parts of the Earth now cold were once warm and vice versa.

The coup de grace to an unchanging Earth was the progression shown by the fossil record, 
leading from the simplest life forms in Precambrian rocks to modern Homo sapiens. Lyell 
accepted evolution only in the 1866 edition of his Principles and then, Gould believes, only 
because “it permitted him to preserve all other meanings of uniformity.”

One type of uniformitarianism amounts to the statement that geology is a science; the second, 
which requires the adoption and maintenance of an a priori position regardless of the evidence, 
amounts to the statement that geology is not a science.

(p.8) In a 1905 book titled The Founders of Geology, Sir Archibald Geikie, from whom we will 
hear more, wrote that Lyell became “the great high priest of Uniformitarianism—a creed which 
grew to be almost universal in England during his life, but which never made much way in the 
rest of Europe, and which in its extreme form is probably now held by few geologists in any 
country.”

Notes:

(1.) S. P. Thompson, The Life of William Thomson, Baron Kelvin of Largs, vol. 1 (London: 
Macmillan, 1910), 185.

(2.) Ibid., 14.

Mathematical Journal 2 (1841).
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(7.) Ibid., 42.


(9.) J. Playfair, *Biographical Account of the Late Dr. James Hutton* (Edinburgh: Royal Society of Edinburgh, 1805), 73.


(15.) See Gould, *Time’s Arrow, Time’s Cycle*.

(16.) Ibid., 119.


